REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

1. AGENCY USE ONLY (Leave Blank)

2. REPORT DATE 6/10/2001

3. REPORT TYPE AND DATES COVERED
Special Technical Summary

4. TITLE AND SUBTITLE
Nanomechanical Devices for High Speed and Low-Power Electronics

5. FUNDING NUMBERS
DASG60-01-P-0057

6. AUTHOR(S)
W.R. Lawrence

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Tesla Technologies Inc
9040 Executive Park Dr., Suite 246
Knoxville TN 37923

8. PERFORMING ORGANIZATION REPORT NUMBER SBIR-I-BMDO-USASMDC-CDRL-A001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Space and Missile Defense
P.O. Box 1500
Huntsville AL 35807

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

20010614 122

12 a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. ABSTRACT (Maximum 200 words)

We propose to develop a new class of semiconductor devices and nano-electro-mechanical systems (NEMS). These new systems are based on the formation of multiple quantum wells (MQW) and multiple quantum barriers (MQB) for electron confinement. Our efforts will significantly impact the important new area of nano technology/electronics. Our unique approach will allow us to study phenomena and interactions at room temperature that currently can only be measured at cryogenic temperatures. We will produce multiple quantum barriers (for example SiO_2 and SiNx) on Si microstructures to form a composite quantum barrier. These composite energy barriers, formed by coupling semiconductors through multiple thin oxide layers, allow us to actively manipulate the height of the resulting effective energy barrier. In fact, the effective energy barrier can be modulated (raised as well as lowered) by applying an external electric field or a mechanical stress. Finally, we will use quantum point contacts to form a novel nanomechanical electron transistor in which electron transport can be actuated by simply bending the microstructure. GHz frequencies are possible in such devices under the right circumstances. Feasibility versions of both a nano-mechanical transistor and a tunable IR detector will be attempted.

14. SUBJECT TERMS
Nano-Electronics, NEMS, Nano-Transistors, Bandgap Engineering

15. NUMBER OF PAGES
3 Excluding Transmittal Letter

16. PRICE CODE

17. SECURITY CLASSIFICATION OR REPORT	18. SECURITY CLASSIFICATION ON THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	**UNCLASSIFIED**	**UNCLASSIFIED**	

NSN 7540-01-280-5500

Standard Form 298 (Rev.2-89)
Prescribed by ANSI Std. 239-18
298-102

Nanomechanical Devices for High-Speed Low-Power Electronics

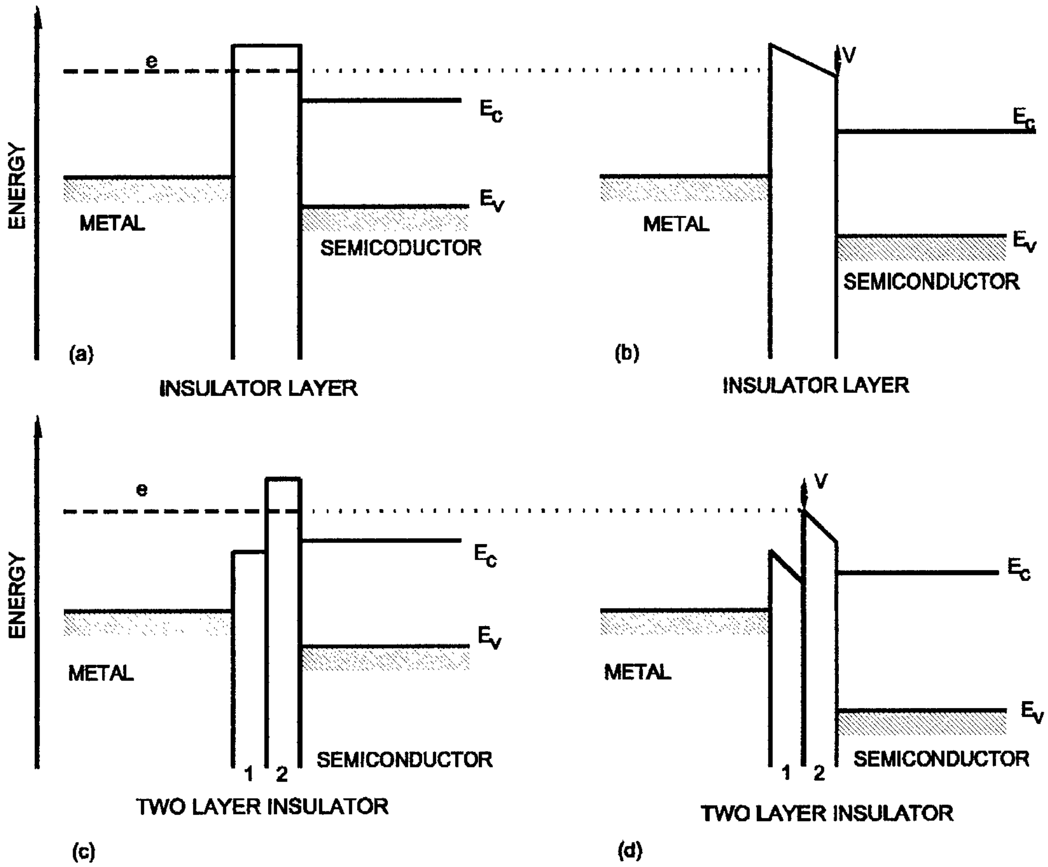
William R. Lawrence
Tesla Technologies Inc
P.O. Box 31378
Knoxville TN 37923

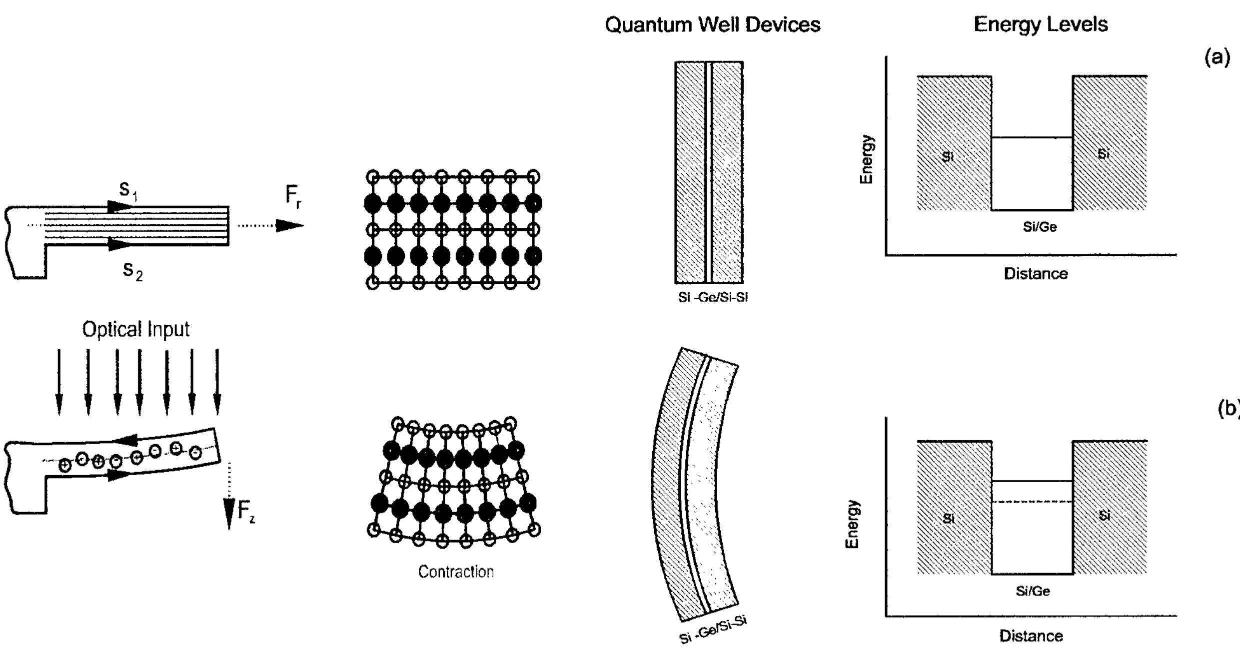
The limitations in size, cost, speed, and heat dissipation in present microelectonics are links paramters that can be delt with more directly at the nano-scale where quantum effects can be exploited with nanomechanics. Over the past decade the fast growing field of micro-electro-mechanical systems (MEMS) has opened-up new possibilities for micro-device applications using phenomena and effects important at the micro-scale. As a natural extension, nano-electro-mechanical systems (NEMS) can provide additional opportunities for the "discovery" and manipulation of unique phenomena at the nano-scale. Manipulation of quantum barriers at the nano-scale level using multiple insulator layers, in what we now term as semiconductor-multiple-insulator-metal-systems (SMIMS), can lead to a new generation of more efficient semiconductor devices. Furthermore, multiple quantum wells (MQW), multiple quantum barriers (MQB), and quantum point contacts (QPC) grown on top of micro-mechanical structures can provide efficient means for ballistic restriction and electron confinement.

Low dimensional semiconductor quantum structures have recently attracted much attention owing to their interesting properties in quantum physics and potential applications in microelectronics and optoelectronic devices. Recently it has become apparent that as systems become smaller and smaller in size (from millimeters to micrometers to nanometers), new phenomena manifest themselves in multiple time scales and dimensions. This is important because it means that properties of materials can be manipulated at the nano-scale level. This manipulation of useful quantum effects can be modulated with electric fields, photons (electron hole pair generation), and even mechanical stress. These control parameters become particularly user friendly when these nano-structures reside on larger micro-devices. These composite devices can be of a material and dimension to have resonance frequencies well over a GHz, while shuttling only a few electrons per cycle. This could have an enormous effect on device size / heat dissipation compared to conventional technology.

We propose to develop and study a new class of semiconductor NEMS devices. These new systems are based on the formation of MQW and MQB used for electron confinement and QPC within micromechanical structures used for ballistic electron restriction, in microstructures. Our efforts will significantly impact the important new area of nano technology/electronics. To our knowledge the proposed work will be the first ever attempts to develop nanostructures as part of micromechanical systems and to measure electron transport phenomena in nanostructures using these micromechanical devices. Our unique approach will allow us to study phenomena and interactions at room temperature that currently can only be observed at cryogenic temperatures.

Our efforts may directly lead to the development of a revolutionary class of micro/ nano mechanical devices such as "single" electron transistors and tunable photon detection devices that rely on actuated (stressed) quantum wells (QW), quantum barriers (QB), and quantum point contacts. New capabilities in chemical sensing and energy conversion devices using modulated electron energy barriers would also result if feasibility can be demonstrated for this approach. Once the technology area is established, other devices will result that are not obvious at this point. The technology transfer possibilities seem very promising since all of the fabrication tools already exist, although much process development will be required to optimize and integrate the micro and nano fabrication tools that have been developed over the last decade.


ENERGY
e
E_C
E_V
METAL
SEMICODUCTOR
(a)
INSULATOR LAYER
V
E_C
E_V
METAL
SEMICONDUCTOR
(b)
INSULATOR LAYER
ENERGY
e
E_C
E_V
METAL
1
2
SEMICONDUCTOR
TWO LAYER INSULATOR
(c)
V
E_C
E_V
METAL
1
2
SEMICONDUCTOR
TWO LAYER INSULATOR
(d)


S_1
F_r
S_2
Optical Input
F_z
Contraction
Quantum Well Devices
Energy Levels
(a)
Si
Si
Si/Ge
Energy
Distance
Si -Ge/Si-Si
(b)
Si
Si
Si/Ge
Energy
Distance
Si -Ge/Si-Si